Demonstration Storms for Identifying Climate Vulnerability

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WISCONSIN INITIATIVE ON CLIMATE CHANGE IMPACTS

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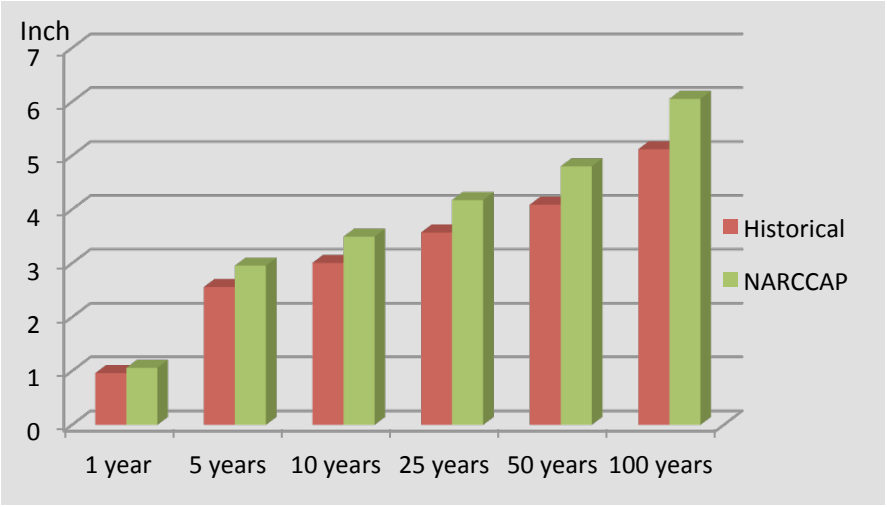
Overview

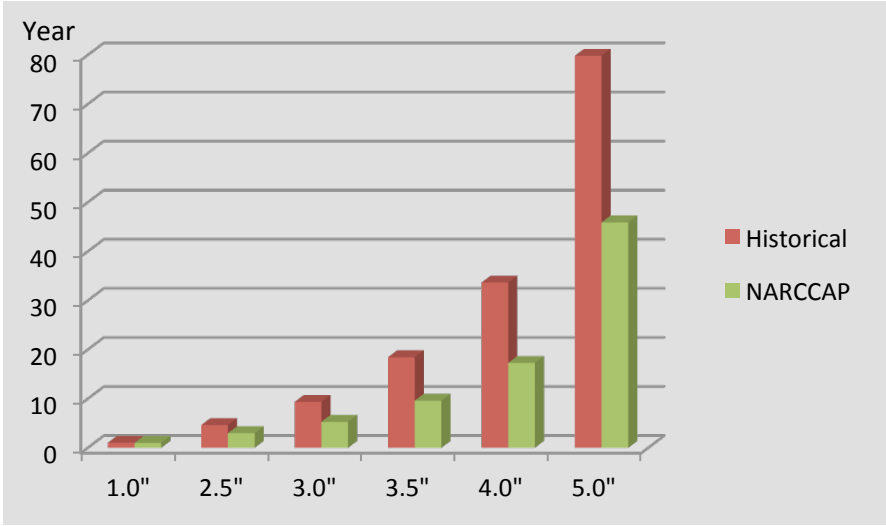
- General Circulation Models (GCMs) downscaled for Wisconsin predict significant increases in the magnitude and frequency of large rainfall events.
- But there are very large variations across models, limiting their direct use for water resource design, management, and planning.
- We believe climate adaptation should focus on
  - Identify vulnerabilities;
  - Adapting design and management methods to reduce the most critical vulnerabilities.
- Storm transposition appears to be useful adaptation tool based on our experience in Wisconsin.

Regional Climate Model (RCM) Projections for Wisconsin

Comparisons of RCM projections of storm intensity and recurrence interval for the periods 1971-2000 and 2041-2070



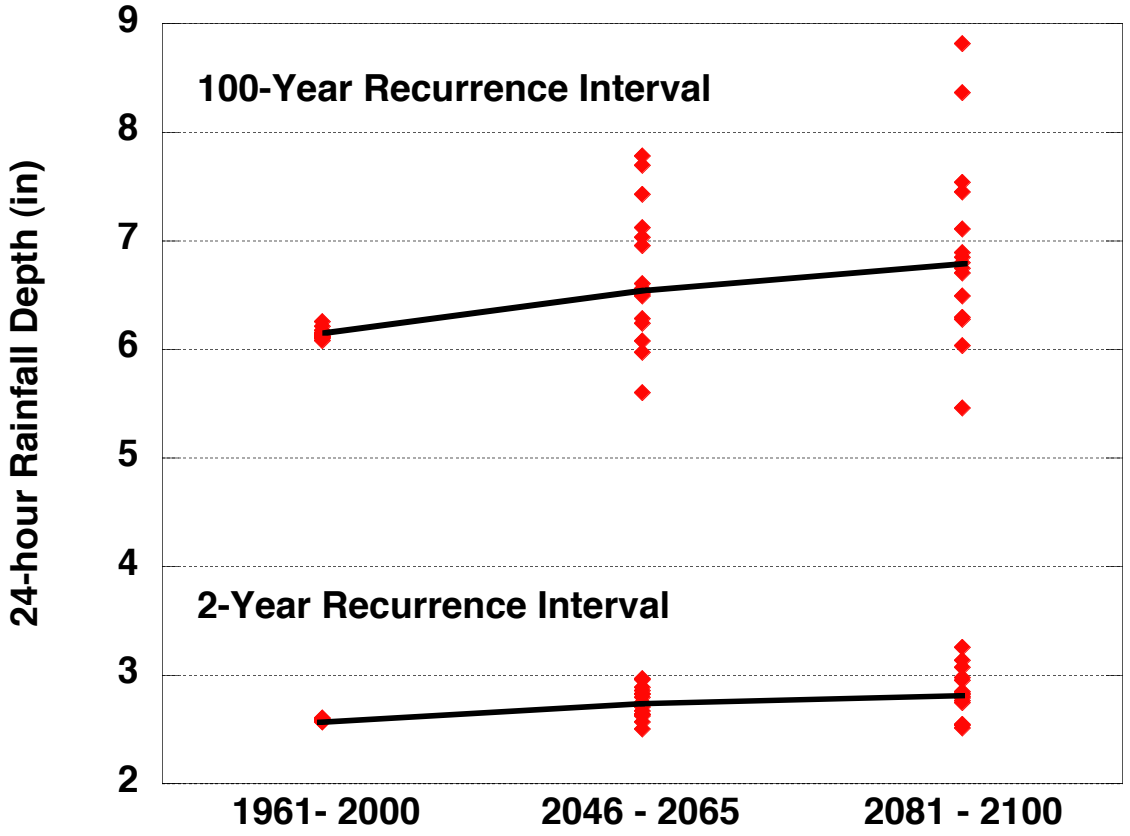
Vavrus and Behnke



Vavrus and Behnke

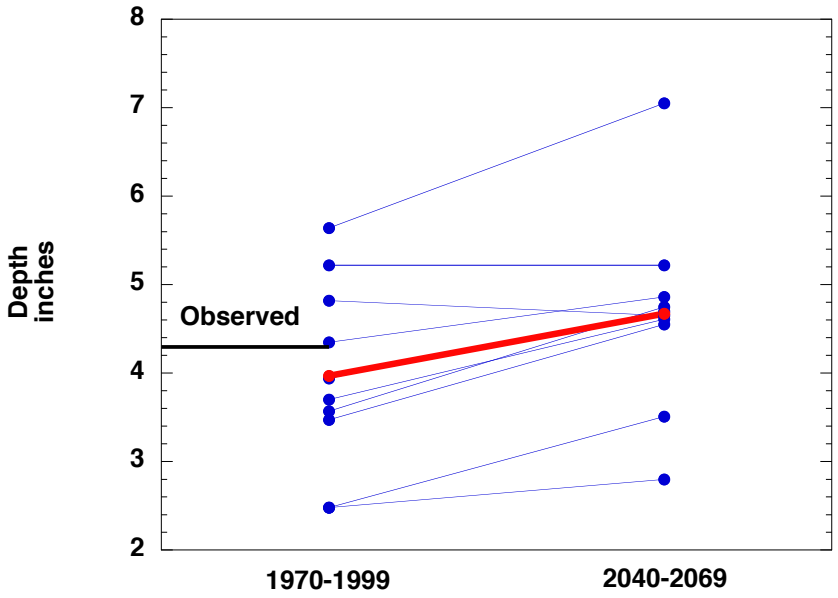
Both intensity and RI are projected to increase.

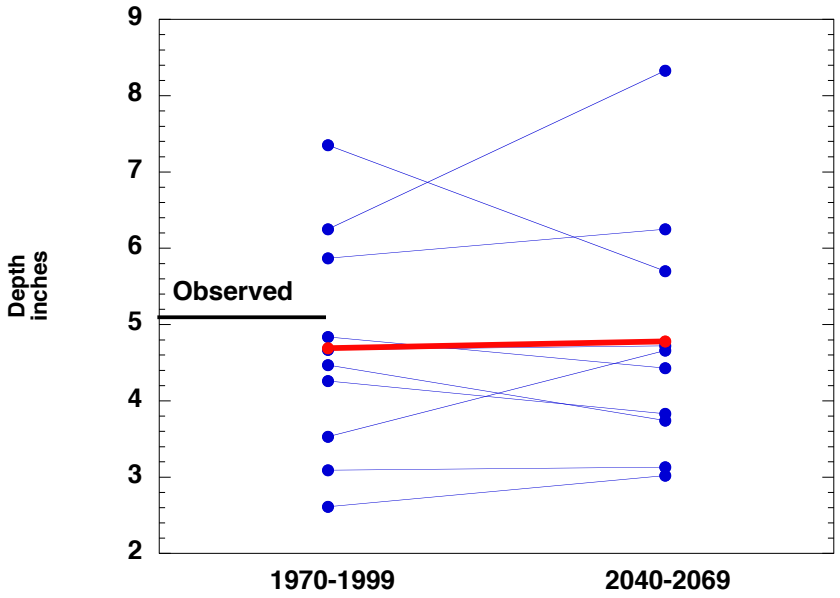
Statistically Downscaled 24-Hour Rainfalls for Madison



Based on statistically downscaled data developed by Kucharik, Lorenz, Notaro, and Vimont, UW-Madison.

Regional Climate Model (RCM)
100-Year, 24-Hour Rainfalls



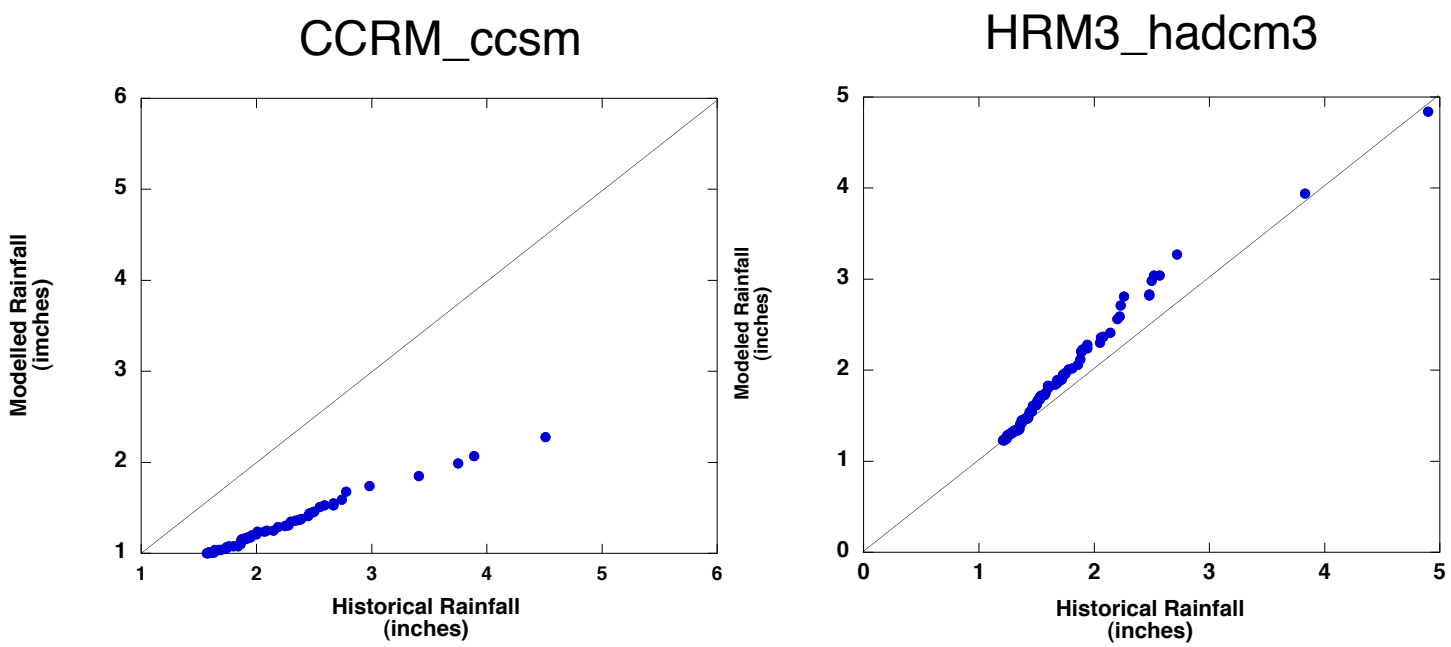


Red bar indicates the mean.

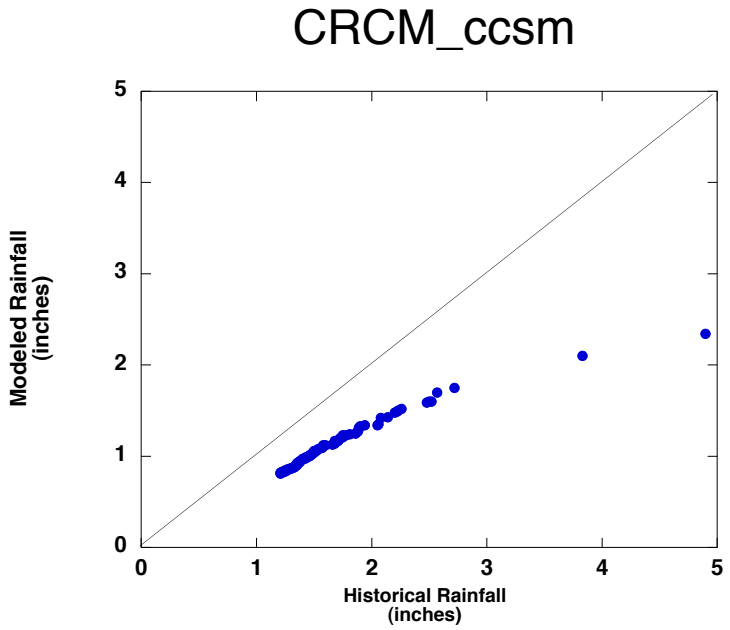
Green Bay

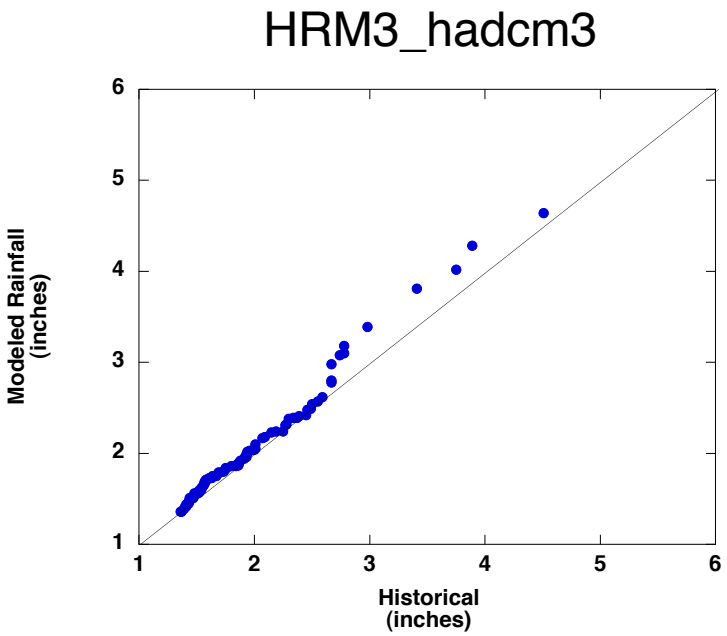
Milwaukee

Quantile-Quantile Plots for Top 100 Daily RCM Rainfalls: Madison

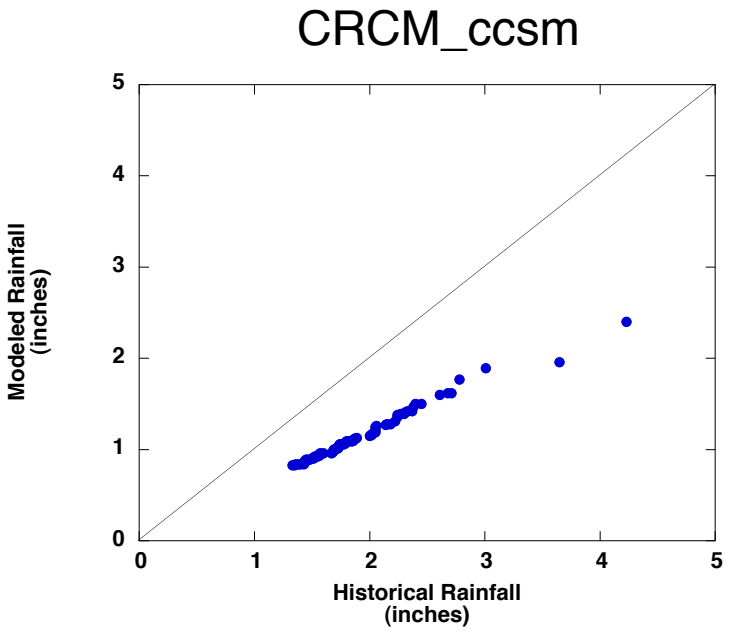


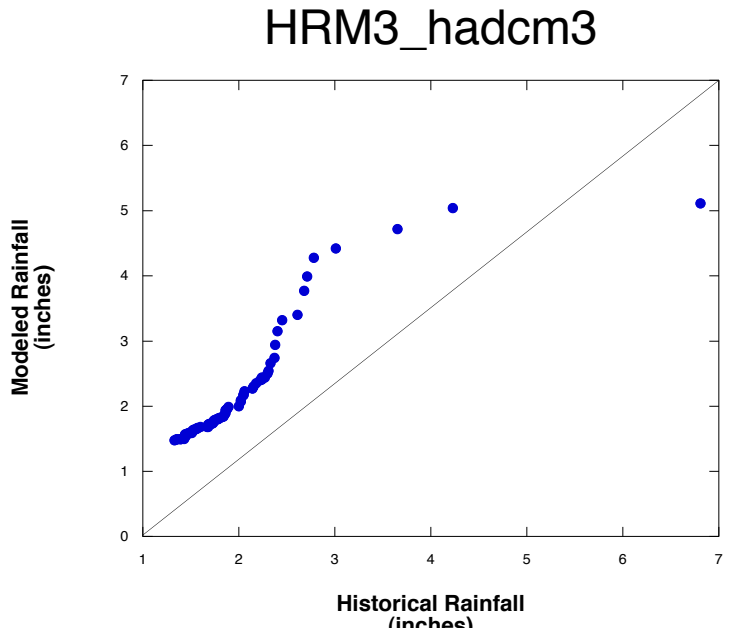
Quantile-Quantile Plots for Top 100 Daily Rainfalls: Green Bay





Quantile-Quantile Plots for Top 100 Daily Rainfalls: Milwaukee





Given GCM uncertainties,
how shall we “adapt” water management to likely increases in the magnitude and frequency of extreme precipitation events?

Assess Vulnerability

- Floodplains
- At-risk road-crossings
- Stormwater BMPs
- Sanitary sewer inflow and infiltration
- Emergency response capacity
- Wells and septic systems
- Hazardous materials storage

Build Long-Term Resilience

- Modify structures
- Change design standards
- Strengthen ordinances

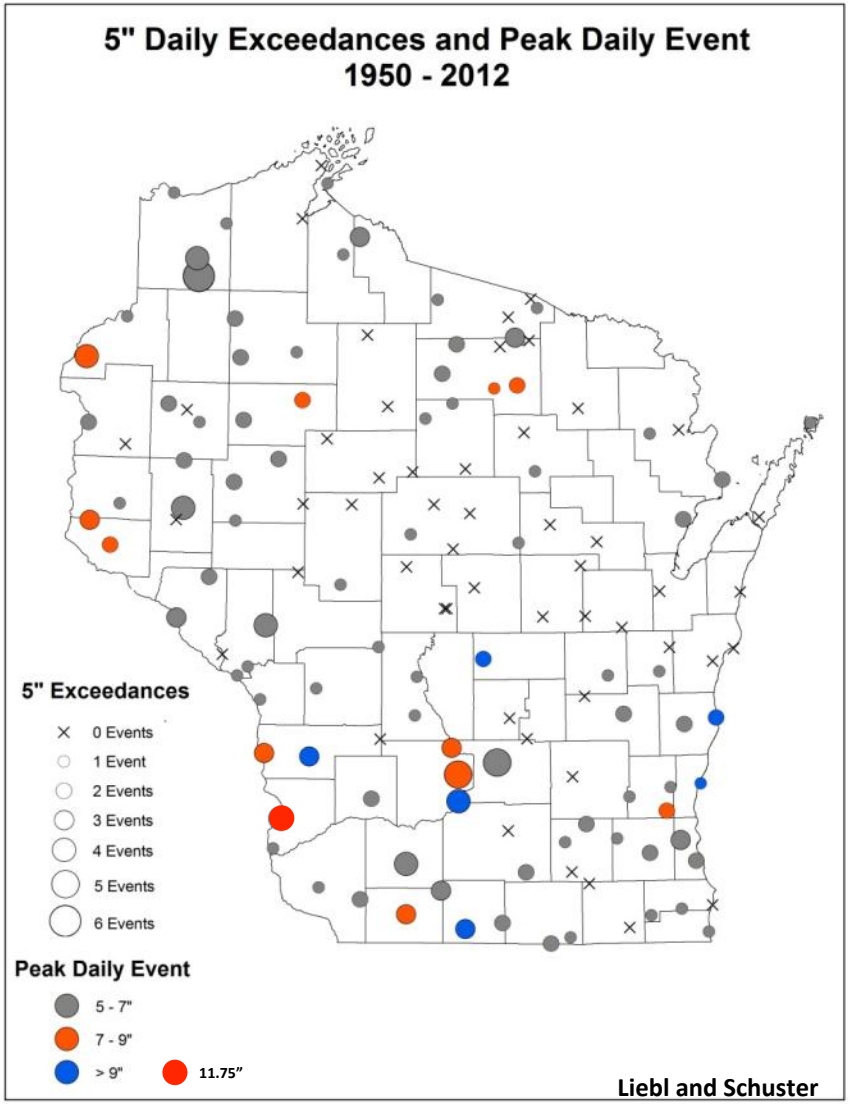
How can we best identify vulnerabilities?

We can begin by focusing on places that have not been hit by extreme events in recent memory.

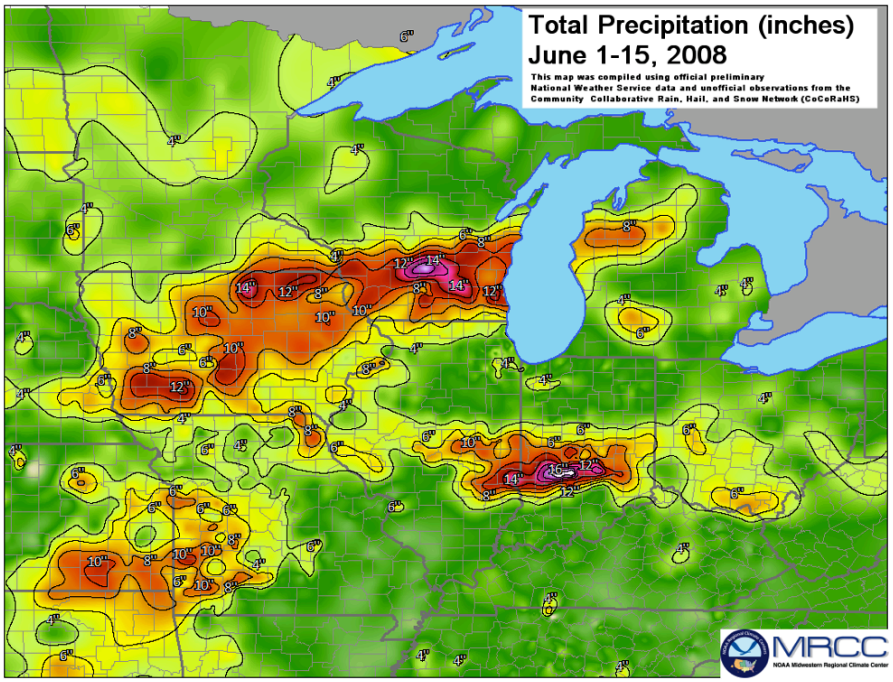
Large Wisconsin Rainfalls Since 1950

Note that many gages have not measured a daily event larger than 5 inches since 1950, while others have measured over 9 inches.

Infrastructure expansion in such areas may be vulnerable.



We then model the behavior of systems when stressed by an extreme storm that recently occurred somewhere nearby. We call this storm transposition.



Past Uses of Storm Transposition

- Design of the flood control practices associated with the Miami Conservancy District (*Arthur Morgan*)
- Development of probable maximum precipitation
- Floodplain mapping based on continuous rainfall-runoff modeling (*Bradley and Potter*)
- Evaluation of vulnerabilities to flooding, landslides, and coastal erosion and inundation in California (*USGS*)

Basic Steps

- Reconstruct spatial and temporal pattern of one or more major historical storms based on NEXRAD and rainage data.
  - Requires specialized software.
- Use the transposed storm as input to a hydrologic model of "system" under investigation.
  - Requires specialized software.
  - To make fullest use of rainfall data, model should be able to predict at a sub-daily time step.
- Use the storm and model to explore management questions.

Example: Yahara Lakes Watershed

This is an urbanizing watershed that has experience some flooding in the past, but was south of the most extreme part of the 2008 storm.

- What would have happened had the 2008 storm been centered on the lakes?
- Are the Dane County stormwater ordinances sufficiently restrictive with respect to volume control?
- What about closed watersheds?

Stakeholder Participation

All steps are being conducted in consultation with a stakeholder group that includes representatives of the

- City of Madison;
- Dane County Land & Water Resources Dept;
- Madison Metropolitan Sewer District;
- Wisconsin Department of Natural Resources.

Rainfall Data

NOAA-NCDC NEXRAD Data

- Reflectivity of radar signal -> precipitation depth
  - High Spatial Resolution
- Processed by Prof. Jim Smith and Mary Lynn Baeck at Princeton University
  - Mean field bias correction using USGS and CoCaRaHS gages (~130)
- 15-minute cumulative precipitation depths
- Spatial coverage by three radar stations
  - LaCrosse, Milwaukee, and Davenport

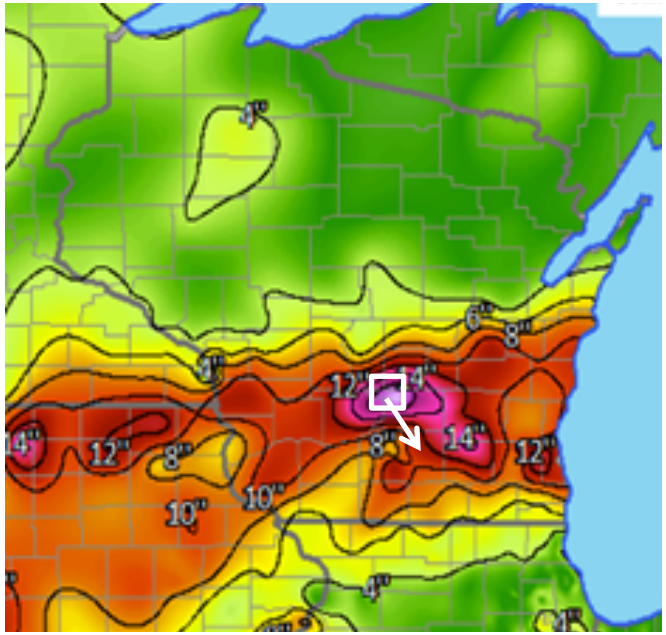
Software Development

TranStorm

- Shifts location of storm rainfall to either
  - Optimize total rainfall over a designated area, or
  - To respond to user's specifications
- Calculates total rainfall at centroid of model subareas.

Preliminary Results

What would have happened if the 2008 rainfall had been centered over the Yahara Lakes?



Lake Mendota

	Rainfall	Rise	Stage	Outflow
2008 storm	10.7″	2.3 ′	852 ′	632 cfs
Transposed storm	13.6″	2.9 ′	853 ′	752 cfs
100-year flood			852 ′	

Note that the 853’ stage is almost a foot higher than the outlet structure!

Other Applications

- Black Earth Creek
  - Largely rural watershed that will likely have significant population increases.
  - Should the county increase detention standard from a 10-year event to a 100-year event?
- Starkweather Creek
  - Watershed above the Dane County Airport is undeveloped.
  - Is the conveyance through the AP sufficient?

Conclusions

- For much of the US, the magnitude and frequency of large rainfall events is likely to increase under climate change.
- But there are very large variations across climate models, limiting their direct use for water resource design, management, and planning.
- Instead, we believe climate adaptation should focus on
  - Identify vulnerabilities;
  - Adapting design and management methods to reduce the most critical vulnerabilities.
- Storm transposition appears to be a useful adaptation tool based on our experience in Wisconsin.


QUESTIONS?